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St. Regis Indian Reservation

Beaver Meadow Creek
Improved Drainage Study

Prepared
for the Department of the Interior,
Bureau of Indian Affairs

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US Army Corps
of Engineers
Buffalo District

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December 1988

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This report presents the Corps' assessment of flooding of Beaver Meadow Road on the St. Regis Indian Reservation near Hogansburg, N.Y. In addition, the report provides the Corps' preliminary design of five possible plans of improvement which were based on the needs expressed by the St. Regis Mohawk Tribe and designed using available approximate topographic and survey data. The primary need of the tribe is for the

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CONT

reduced frequency of flooding of Beaver Meadow Road. A secodary concern is for improved drainage upstream of Beaver Meadow Road to facilitate agricultural or residential development. Therefore of the five plans of improvement presented, three plans (1,2, and 3) would provide for reduced road flooding only, while two plans (4 and 5) would provide both road protection and improved upstream land drainage.

ABSTRACT

This report was prepared in accordance with the August 27, 1987 Memorandum of Agreement between the Buffalo District Corps of Engineers and the Department of the Interior, Bureau of Indian Affairs, Eastern Area Office. It presents the Corps' assessment of flooding of Beaver Meadow Road on the St. Regis Indian Reservation near Hogansburg, New York. In addition, the report provides the Corps' preliminary design of five possible plans of improvement which were based on the needs expressed by the St. Regis Mohawk Tribe and designed using available approximate topographic and survey data.

The primary need of the Tribe is for the reduced frequency of flooding of Beaver Meadow Road. A secondary concern is for improved land drainage upstream of Beaver Meadow Road to facilitate agricultural or residential development. Therefore, of the five plans of improvement presented, three plans (1, 2, and 3) would provide for reduced road flooding only, while two plans (4 and 5) would provide both road protection and improved upstream land drainage.

The five plans would:

1. Add an additional 36-inch cmp at Beaver Meadow Road and perform minor downstream channel clearing. This plan would provide 2-year degree of protection for Beaver Meadow Road. Cost: $18,000.

2. Provide 10-year peak discharge culvert capacity at Beaver Meadow Road and a 10-year capacity channel from Beaver Meadow Road to Pike Creek. Under this plan, no increased channel capacity would be provided upstream of Beaver Meadow Road. Cost: $287,000.

3. Provide 25-year peak discharge culvert capacity at Beaver Meadow Road and a 25-year capacity channel from Beaver Meadow Road to Pike Creek. As with Plan 2, no increased channel capacity would be provided upstream of Beaver Meadow Road. Cost: $372,000.

4. Provide a 10-year capacity channel upstream of Beaver Meadow Road, 10-year capacity culverts at Beaver Meadow Road, and a 10-year capacity channel from Beaver Meadow Road to Pike Creek. Cost: $1,171,000.

5. Provide a 10-year capacity channel upstream of Beaver Meadow Road, 25-year capacity culverts at Beaver Meadow Road, and 25-year capacity channel from Beaver Meadow Road to Pike Creek. Cost: $1,341,000.

Based on the St. Regis Mohawk Tribe's desire for agricultural or residential development upstream of Beaver Meadow Road, and the New York State Department of Transportation's preference for 10-year peak discharge culvert capacity at Beaver Meadow Road, Plan 4 is the recommended plan of improvement. However, if the Tribe decides that improved land drainage upstream of Beaver Meadow Road is not economically justified or is not warranted by future land use plans, then Plan 2 is the recommended plan of improvement.

Before any plan is implemented, it should undergo a final design analysis based on accurate survey and topographic data. Therefore, it is recommended that the St. Regis Mohawk Tribe pursue additional funding for a second stage of study which would provide detailed profiles and cross sections of Beaver Meadow Road and Beaver Meadow Creek, along with refinement of the hydrologic analysis, final design, and cost of construction, for the selected plan of improvement.

BEAVER MEADOW CREEK
IMPROVED DRAINAGE STUDY

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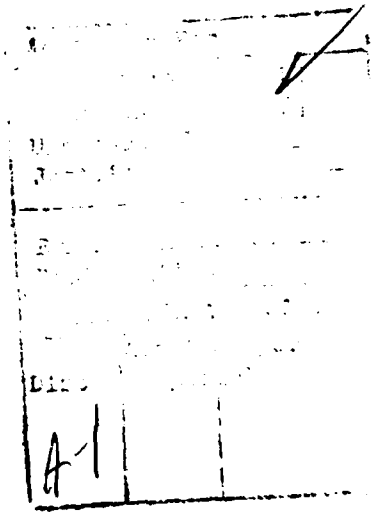

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1 INTRODUCTION

This report presents the Buffalo District Corps of Engineers' evaluation of flood and drainage problems along Beaver Meadow Creek on the St. Regis Indian Reservation near Hogansburg, New York. Its purpose is to present the preliminary design and costs of various alternatives for reducing the inundation of Beaver Meadow Road and improving the drainage of the Beaver Meadow Creek watershed.

2 EXISTING CONDITIONS

A. Watershed Characteristics

The Beaver Meadow Creek watershed is shown on Plate 1. The watershed is approximately 3.5 miles long and 2 miles wide with a total drainage area of 4.2 square miles at its mouth at Pike Creek. The drainage area of Beaver Meadow Creek upstream of Beaver Meadow Road is 3.5 square miles.

The Beaver Meadow Creek watershed exhibits diversity in topography, soil types, and land use. With respect to topography, much of the perimeter of the watershed is hilly while the areas adjoining the creek are very flat and poorly drained. The average slope of the main channel of Beaver Creek varies from 0.0005 ft/ft upstream of Beaver Meadow Road to 0.001 ft/ft downstream of Beaver Meadow Road.

Soil types within the watershed are also varied. The hilly regions along the perimeter of the watershed exhibit moderately well drained soils classified as type B by the Soil Conservation Service (SCS). Soils located near the base of the hills and along the floodplain of the creek are more poorly drained fine textured soils classified as types C and D by the SCS.

Land use in the watershed consists primarily of woods and brush. Agricultural land use in the watershed has declined in recent years due to low farm income and inadequate drainage of lowland areas. Given the above soil types and land uses, and SCS curve number of 71 was calculated for the watershed and used in subsequent runoff analyses (Table 1).

Table 1. SCS Curve number characteristics for Beaver Meadow Creek Watershed

Hydrologic Soil Group	Cover Description	Curve Number	Percent of Watershed
D	Brush-fair cond.	77	35
D	Woods-fair cond.	79	15
C	Brush-fair cond.	70	20
C	Woods-fair cond.	73	10
B	Brush-fair cond.	56	20

B. Hydrologic Analysis

The discharge-frequency relationships for Beaver Meadow Creek were determined using the SCS computer program TR-20. Input to the computer program included drainage areas, channel characteristics, time of concentration, culvert rating curves, land use curve numbers, and rainfall amounts.

For this analysis, the watershed was divided into 6 subareas, 5 of which are upstream of Beaver Meadow Road (Plate 1). The characteristics of these drainage areas are presented below in Table 2.

Table 2. Characteristics of Beaver Meadow Creek Subareas

Subarea	Drainage Area (mi^2)	Time of Concentration (hours)	Travel Time Through Subarea (hours)
1	0.83	3.5	-
2	0.40	5.0	-
3	1.51	6.1	3.3
4	0.75	4.4	-
5	0.14	1.5	0.5
6	0.53	2.7	0.9

Table 3 presents the 24-hour rainfall amounts for various return periods which were used in determining the discharge-frequency relationships for Beaver Meadow Creek. The return periods for each of the 24-hour rainfall amounts were accepted as the return periods for the peak discharges they produced. The SCS 24-hour type II rainfall distribution was used in applying each 24-hour rainfall amount to the SCS dimensionless unit hydrograph contained in TR-20. Average (SCS type II) antecedent soil moisture conditions were assumed for each runoff calculation.

Table 3. 24-Hour Rainfall-Frequency Relationship(1)

Return Period (years)	24-Hour Rainfall (inches)
1	1.9
2	2.2
5	3.0
10	3.4
25	3.9
50	4.4
100	4.7

(1) Source: U.S. Weather Bureau. 1961. Technical Paper No. 40. Rainfall Frequency Atlas of the United States

Plate 2 presents the discharge-frequency relationships for Beaver Meadow Creek at Beaver Meadow Road and at Pike Creek, respectively. Plate 2 shows that the discharge-frequency curve for Beaver Meadow Creek at Beaver Meadow Road is higher than the curve at Pike Creek. This is due to the inadequate capacity of the 2 existing 36 inch corrugated metal pipe (cmp) culverts which causes runoff waters to pond upstream of Beaver Meadow Road and thereby reduce downstream discharges.

C. Beaver Meadow Road Inundation

According to local residents, Beaver Meadow Creek floods Beaver Meadow Road every year. The depth of flooding over Beaver Meadow Road has been estimated by residents to be 3 to 8 inches. Based on the profile of the road, determined from 5 ft. contour interval maps provided by the State of New York Department of Transportation (NYSDOT), about 600 ft. of roadway would be flooded if covered by 6 inches of water to elevation 182.5 (2) (Plate 3).

Plate 4 presents the elevation vs. discharge relationship (rating curve), for the 2 existing 36 inch diameter cmp's at Beaver Meadow Road, as well as the rating curves for additional 36 inch culverts. The rating curve for the 2 existing culverts indicates a discharge through the culverts of 100 cfs when the Beaver Meadow Creek water level just exceeds the top of the road (elevation 182.0). Based on the discharge-frequency curve of Plate 2, a peak discharge of 100 cfs at Beaver Meadow Road is approximately a 2-year event indicating that Beaver Meadow Road should be flooded, to some degree, every other year on the average rather than every year as witnessed by local residents.

This difference between computed flood frequency and reported flood frequency, could be due to inaccuracies in the computed discharge-frequency curve (Plate 2), and the culvert rating curves (Plate 3). Another possibility, is the partial blockage of the culverts by ice or debris during spring snowmelt and rainfall runoff events which prevents the culverts from functioning at their full capacity. Regardless of the reason for the difference between the computed and observed frequency of Beaver Meadow Road inundation, the computed flood recurrence interval is on the same order of magnitude as reported, is too frequent, and does not meet NYSDOT standards for culvert capacity.

NYSDOT recommends that culverts under secondary roads, such as Beaver Meadow Road, be designed to pass the 10-year to 25-year peak discharge with the upstream water surface elevation at least 2 ft. below the shoulder of the road. In the case of Beaver Meadow Road, the shoulder is at elevation 181.7, making 179.7 the upstream design water surface elevation. Entering the culvert rating curve of Plate 4 at elevation 179.7, yields a discharge of 56 cfs which is approximately the 1-year discharge computed by TR-20 and well below NYSDOT design criteria. The following section presents alternatives to increase the discharge of Beaver Meadow Creek beneath Beaver Meadow Road and thereby reduce the frequency of flooding of Beaver Meadow Road.

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(2) All elevations in this report are in feet, National Geodetic Vertical Datum (NGVD).

3. IMPROVED CONDITIONS

Five alternatives or plans of improvement to reduce the frequency of flooding of Beaver Meadow Road are presented in this report. Some of these plans not only reduce the frequency of Beaver Meadow Road inundation, they also improve the drainage of Beaver Meadow Creek upstream of Beaver Meadow Road, thus improving conditions for farming and residential development. The five plans presented below are not exhaustive, but rather present a range of drainage options and their associated costs.

The five plans are:

1. Add an additional 36 inch cmp at Beaver Meadow Road and perform minor downstream channel clearing.

2. Provide 10-year peak discharge culvert capacity at Beaver Meadow Road and a 10-year capacity channel from Beaver Meadow Road to Pike Creek. Under this plan, no increased channel capacity is provided upstream of Beaver Meadow Road.

3. Provide 25-year peak discharge culvert capacity at Beaver Meadow Road and a 25-year capacity channel from Beaver Meadow Road to Pike Creek. As with Plan 2, no increased channel capacity is provided upstream of Beaver Meadow Road.

4. Provide a 10-year capacity channel upstream of Beaver Meadow Road, 10-year capacity culverts at Beaver Meadow Road, and a 10-year capacity channel from Beaver Meadow Road to Pike Creek.

5. Provide a 10-year capacity channel upstream of Beaver Meadow Road, 25-year capacity culverts at Beaver Meadow Road, and 25-year capacity channel from Beaver Meadow Road to Pike Creek.

Plans 1, 2, and 3 reduce the frequency of Beaver Meadow Road inundation and provide varying degrees of improved drainage from Beaver Meadow Road to Pike Creek. These options, however, provide limited improvement in drainage upstream of Beaver Meadow Road. Plans 4 and 5 not only reduce the frequency of Beaver Meadow Road inundation but also provide significant channel improvement and land drainage upstream of Beaver Meadow Road. The five drainage alternatives are presented in detail below.

A. Plan 1

This alternative provides a minimal improvement in drainage at minimal cost. Plate 4 shows the potential for increasing the discharge beneath Beaver Meadow Road through the use of additional 36 inch cmp's. At the design headwater elevation of 179.7, three 36 inch culverts could pass 78 cfs compared to 58 cfs for the two existing 36 inch culverts. Seventy-eight cfs is approximately equal to the 2-year discharge while 58 cfs is approximately the 1-year discharge. As evident from Plate 4, increasing the number of 36 inch culverts to 4 or 5 provides little or no improvement in stream drainage.

In addition to adding a 36 inch culvert, the downstream channel should be cleaned out for a distance of 1,100 ft. to assure effective culvert performance. The costs for this plan are presented in Table 4.

Table 4. Costs for Plan 1

Item Description	Estimated Quantity	Unit	Unit Price ($)	Cost ($1,000)
36 in. cmp	45	lin. ft	75	3.4
Bituminous roadway	60	lin. ft	85	5.1
Clear and grub (medium)	0.63	acre	6,000	3.8
Total contractors earnings				12.3
Contingencies (25%)				3.1
Total contractors earnings w/contingencies				15.4
Engineering and design (6%)				0.9
Supervision and administration (12%)				1.8
Total construction cost				18.1

B. Plan 2

The purpose of this alternative is to pass the 10-year discharge beneath Beaver Meadow Road. It assumes that there is little interest in farming the lowland upstream of Beaver Meadow Road and therefore no improvement in upstream drainage is proposed.

The 10-year peak discharge at Beaver Meadow Road is 230 cfs (Plate 2). Two 5-feet diameter cmp's with inverts at elevation 173.7 could pass 230 cfs at the design headwater elevation of 179.7.

For these culverts to function properly, the creek channel downstream from Beaver Medow Road must be deepened and widened to accommodate the 10-year discharge. For the first 3,000 ft downstream from Beaver Meadow Road, the improved trapezoidal channel would be 6 ft deep with a bottom width of 10 ft, 2H to 1V sideslopes, and channel slope of 0.001. The lower 1,000 ft of Beaver Meadow Creek would be about 3 ft deep and increase in bottom width to 30 ft with 2H to 1V sideslopes and a channel slope of 0.001. Plate 5 displays approximate, existing, and improved cross sections for Plan 2. The costs for this plan are presented in Table 5, and include riprap protection for 3 lateral inflow sites along the improved channel.

Table 5. Costs for Plan 2

Item Description	Estimated Quantity	Unit	Unit Price ($)	Cost ($1,000)
60 in. cmp	100	lin. ft	155	15.5
Bituminous roadway	75	lin. ft	85	6.4
Clear and grub (medium)	7.1	ac	6,000	42.6
Channel excavation	12,300	yd^3	10	123.0
18 in. riprap w/6 in. bedding	210	yd^2	35	7.4
Total contractors earnings				194.9
Contingencies (25%)				48.7
Total contractors earnings w/contingencies				243.6
Engineering and design (6%)				14.6
Supervision and administration (12%)				29.2
Total construction cost				287.4

C. Plan 3

Plan 3 is similar to Plan 2, except that Plan 3 provides 25-year discharge capacity for Beaver Meadow Road culverts and 25-year channel capacity for Beaver Meadow Creek from Beaver Meadow Road to the mouth of the creek. Like Plan 2, no channelization of Beaver Meadow Creek is proposed upstream of Beaver Meadow Road.

Plate 2 shows that the 25-year (4-percent exceedence frequency) peak discharge is 300 cfs. To pass 300 cfs at the design headwater elevation of 179.7, three 60 inch cmp's with inverts at 173.7 are necessary. In addition, the channel downstream from Beaver Meadow Road must be enlarged to 300 cfs capacity.

The first 3,000 ft of improved channel downstream of Beaver Meadow Road would be 6 ft deep, and have a bottom width of 15 ft, sideslopes of 2H to 1V, and a slope of 0.001 ft/ft. The lower 1,000 ft of improved channel would taper to 3 ft deep and have a bottom width of 40 ft, sideslopes of 2H to 1V, and slope of 0.001 ft/ft. Typical cross sections of the existing and proposed improved channel are presented on Plate 6. The construction costs associated with this plan are presented in Table 6, and include riprap protection at 3 lateral inflow sites along the improved channel.

Table 6. Costs for Plan 3

Item Description	Estimated Quantity	Unit	Unit Price ($)	Cost ($1,000)
60 in. cmp	150	lin. ft	155	23.2
Bituminous roadway	81	lin. ft	85	6.9
Clear and grub (medium)	7.7	ac	6,000	46.2
Channel excavation	16,850	yd^3	10	168.5
18 in. riprap w/6 in. bedding	210	yd^2	35	7.3
Total contractors earnings				252.1
Contingencies (25%)				63.0
Total contractors earnings w/contingencies				315.1
Engineering and design (6%)				18.9
Supervision and administration (12%)				37.8
Total construction cost				371.8

D. Plan 4

Plan 4 is similar to Plan 2 in that it provides for 10-year discharge capacity through Beaver Meadow Road and the channel downstream of Beaver Meadow Road. Plan 4 differs from Plan 2 in that Plan 4 provides for improved drainage upstream of Beaver Meadow Road. The improved channel upstream of Beaver Meadow Road will improve land drainage for farming but in so doing, will increase the frequency of given discharges in Beaver Meadow Creek. The new discharge-frequency curve resulting from improved drainage upstream of Beaver Meadow Road is presented in Plate 7.

The improved channel upstream of Beaver Meadow Road would be comprised of 2 different sizes. For the reach which extends from 700 ft upstream of Beaver Meadow Road to the upstream reservation boundary, a distance of 7,700 ft, the 10-year discharge is 260 cfs. The trapezoidal channel proposed for this reach would be 6 ft deep and have a bottom width of 15 ft, 2H on 1V sideslopes, and slope of 0.006 ft/ft. From Beaver Meadow Road to a tributary 700 ft upstream of Beaver Meadow Road, the improved channel would have a 10-year capacity of 360 cfs, and be similar to the improved channel described above, except that the bottom width would be 25 ft instead of 15 ft. Approximate cross sections of these reaches appear in Plate 8.

To pass 360 cfs beneath Beaver Meadow Road without exceeding the design headwater elevation of 179.7, the existing culverts must be replaced by four 60 inch cmp's. In addition, for the 4 culverts to be effective, 3,000 ft of creek channel immediately downstream of Beaver Meadow Road should be enlarged to 6 ft deep, 20 ft wide, with 2H to 1V sideslopes and sloped 0.001 ft/ft. This should taper to 3 ft deep, 50 ft wide, with 2:1 sideslopes and slope 0.001 ft/ft for the lower 1,000 ft of channel. Plate 9 displays cross sections for this reach.

Upstream of Beaver Meadow Road, riprap protection would be required at 2 lateral inflow sites, while downstream of Beaver Meadow Road, 3 sites would require riprap. The cost of the riprap protection along with all other Plan 4 costs are presented in Table 7.

Table 7. Costs for Plan 4

Item Description	Estimated Quantity	Unit	Unit Price ($)	Cost ($1,000)
60 in. cmp	200	lin. ft	145	29.0
Bituminous roadway	87	lin. ft	85	7.4
Clear and grub (medium)	23.7	ac	6,000	142.2
Excavation	60,300	yd^3	10	603.0
Riprap	347	yd^2	35	12.1
Total contractors earnings				793.7
Contingencies (25%)				198.4
Total contractors earnings w/contingencies				992.1
Engineering and design (6%)				59.5
Supervision and administration (12%)				119.0
Total construction cost				1,170.6

E. Plan 5

This plan includes a 10-year capacity channel upstream of Beaver Meadow Road just like the one proposed in Plan 4. The four 60 inch culverts in Beaver Meadow Road proposed in Plan 4, are also proposed for Plan 5. The difference between Plan 4 and Plan 5 is that a larger improved channel downstream of Beaver Meadow Road is proposed for Plan 5, which will reduce the tailwater elevation and allow the culverts to pass the 25-year discharge of 470 cfs at the design headwater elevation of 179.7.

The first 3,000 ft of improved channel downstream of Beaver Meadow Road, would be 6 ft deep with a bottom width of 30 ft, sideslopes of 2H to 1V, and a slope of 0.001 ft/ft. The lower 1,000 ft of channel between Beaver Meadow Road and Pike Creek would exhibit a depth of 3 ft, bottom width of 70 ft, with sideslopes and slope the same as above. Typical cross sections for Plan 5 are shown in Plate 10.

Like Plan 4, Plan 5 would require riprap placement at 5 tributary inflow sites long the improved channel. The cost of implementing Plan 5 is presented in Table 8.

Table 8. Costs for Plan 5

Item Description	Estimated Quantity	Unit	Unit Price ($)	Cost ($1,000)
60 in. cmp	200	lin. ft	145	29.0
Bituminous roadway	87	lin. ft	85	7.4
Clear and grub (medium)	24.9	ac	6,000	149.4
Excavation	71,100	yd^3	10	711.0
Riprap	347	yd^2	35	12.1
Total contractors earnings				908.9
Contingencies (25%)				227.2
Total contractors earnings w/contingencies				1,136.1
Engineering and design (6%)				68.2
Supervision and administration (12%)				136.3
Total construction cost				1,340.6

4. CONCLUSIONS

Table 9 summarizes the cost and design characteristics for the 5 plans of improvement presented in this report. The numbers in columns 2, 3, and 4 represent the peak discharge return interval which the channel or culverts are designed to pass (e.g., a 10 in column 3 indicates culvert capacity equal to the 10-year discharge). As evident from column 5 of Table 9, the plans vary greatly in cost depending on the degree of protection desired for Beaver Meadow Road and the choice of improved drainage upstream of Beaver Meadow Road.

Table 9. Cost and Design Summary for Beaver Meadow Creek Alternatives

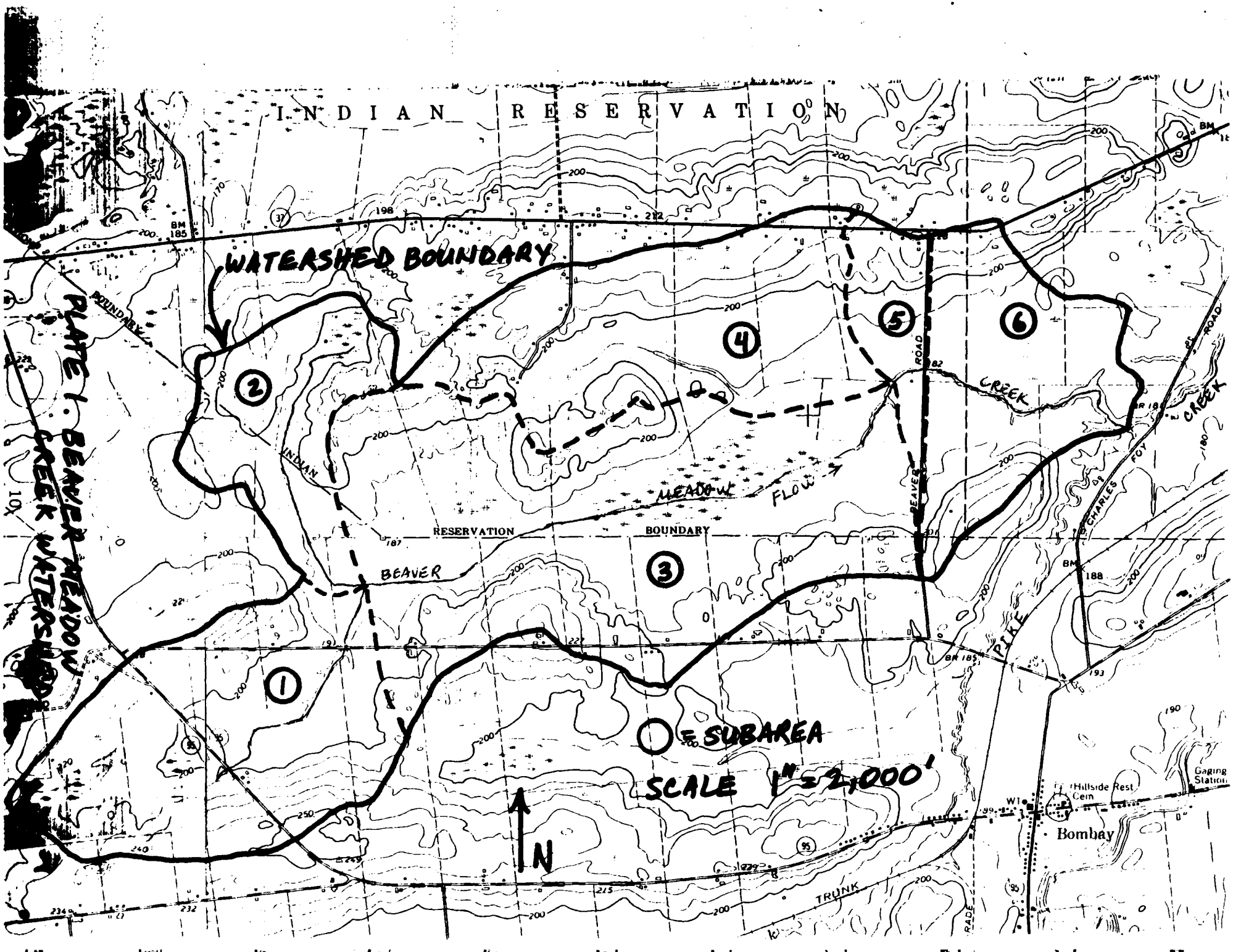
(1) Plan	(2) Design Flow Recurrence Interval of Channel Upst. of Beaver Rd.	(3) Design Flow Recurrence Interval of Culverts at Beaver Rd.	(4) Design Flow Recurrence Interval of Channel Dnst. of Beaver Rd.	(5) Cost ($1,000)
1	<1	2	<1	18
2	<1	10	10	287
3	<1	25	25	372
4	10	10	10	1,171
5	10	25	25	1,341

Plans 4 and 5 provide the same reduction in Beaver Meadow Road flooding as Plans 2 and 3, respectively, but are considerably more expensive than Plans 2 and 3 due to the upstream channelization of Plans 4 and 5. The increased costs of Plans 4 and 5 are not solely the costs of upstream excavation, but also include the costs of enlarging culvert and downstream channel sizes to pass the increased flows caused by the upstream channelization.

5. RECOMMENDATIONS

Based on the St. Regis Mohawk Tribe's desire for agricultural or residential development upstream of Beaver Meadow Road, and the New York State Department of Transportation's preference for 10-year peak discharge culvert capacity at Beaver Meadow Road, Plan 4 is the recommended plan of improvement. However, if the Tribe decides that improved land drainage upstream of Beaver Meadow Road is not economically justified or is not warranted by future land use plans, then Plan 2 is the recommended plan of improvement.

Before any plan is implemented, it should undergo a final design analysis based on accurate survey and topographic data. Therefore, it is recommended that the St. Regis Mohawk Tribe pursue additional funding for a second stage of study which would provide detailed profiles and cross sections of Beaver Meadow Road and Beaver Meadow Creek, along with refinement of the hydrologic analysis, final design, and cost of construction, for the selected plan of improvement.


INDIAN RESERVATION
WATERSHED BOUNDARY
PLATE 1: BEAVER MEADOW CREEK WATERSHED
MEADOW
FLOW
BEAVER
CREEK
INDIAN
RESERVATION
BOUNDARY
BEAVER
CREEK
ROAD
PIKE
TRUNK
ROAD
Hillside Rest Cem
Gaging Station
Bombay
BM 185
BM 188
1
2
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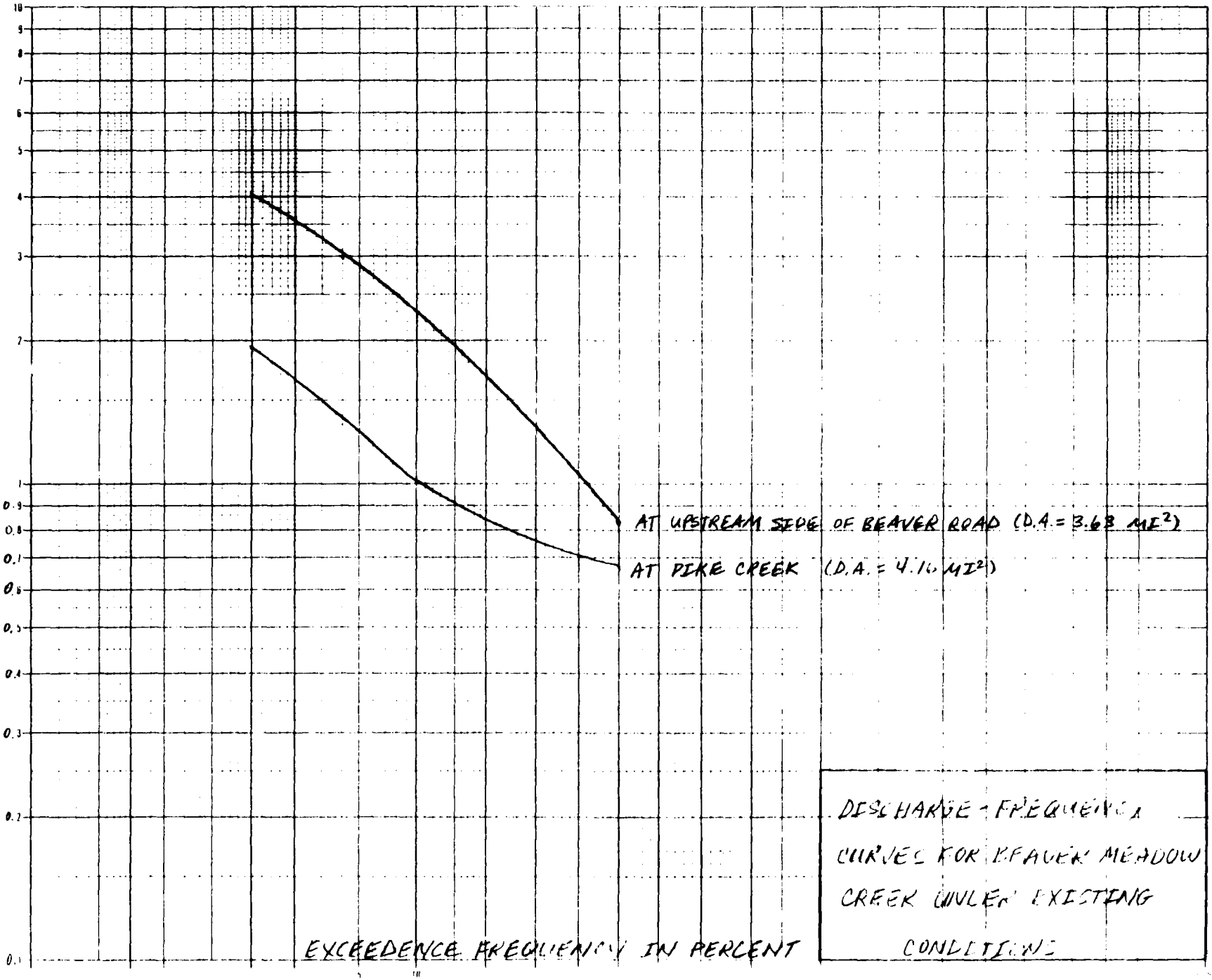
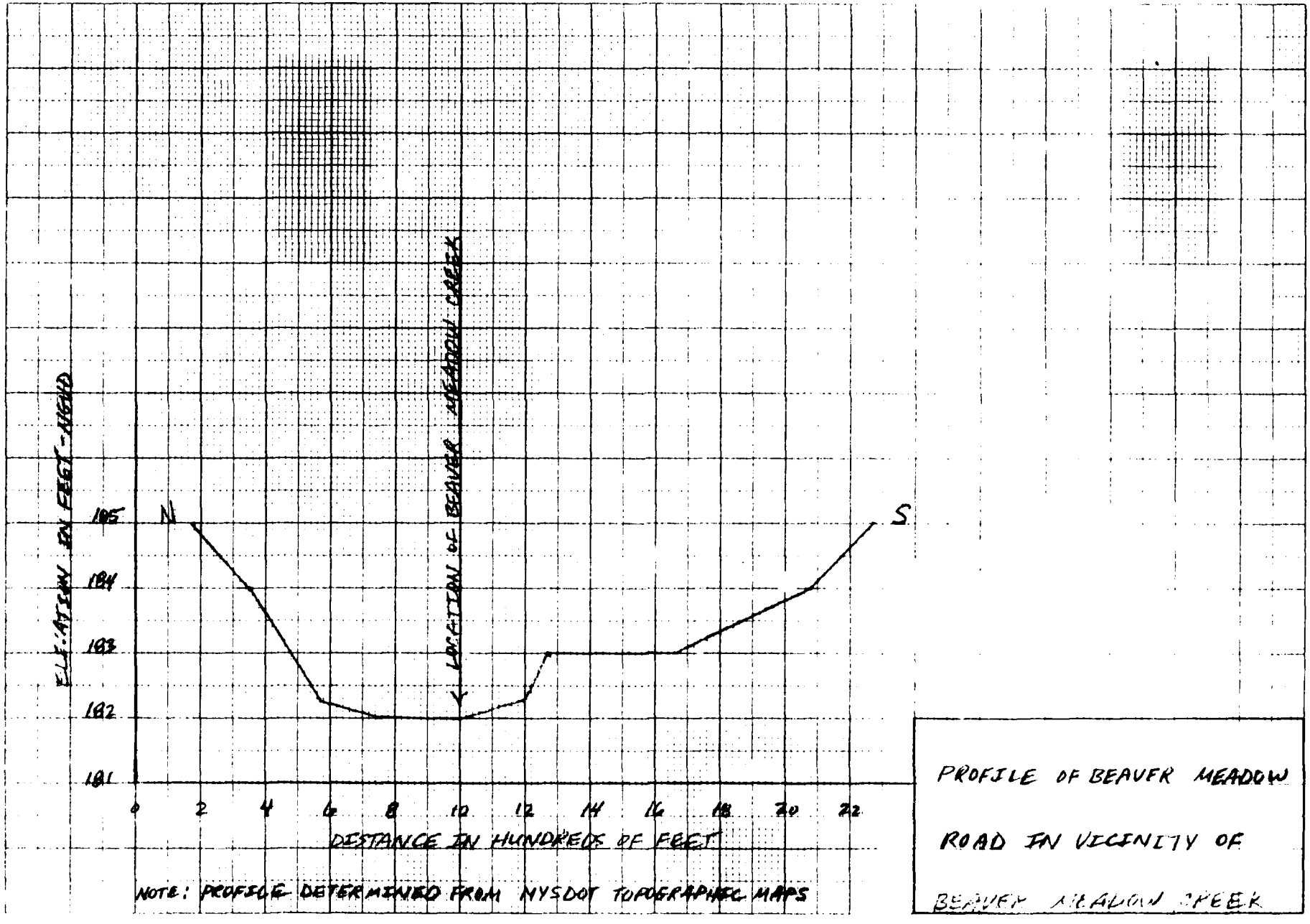

PROBABILITY BY LOGARITHMIC 7 LOG CYCLES SHORT SIDE
DISCHARGE IN HUNDRED CFS
EXCEEDENCE FREQUENCY IN PERCENT
AT UPSTREAM SIDE OF BEAVER ROAD (D.A. = 3.63 MI²)
AT PIKE CREEK (D.A. = 4.16 MI²)
DISCHARGE - FREQUENCY CURVES FOR BEAVER MEADOW CREEK UNDER EXISTING CONDITIONS

PLATE 7

GRAPH PAPER

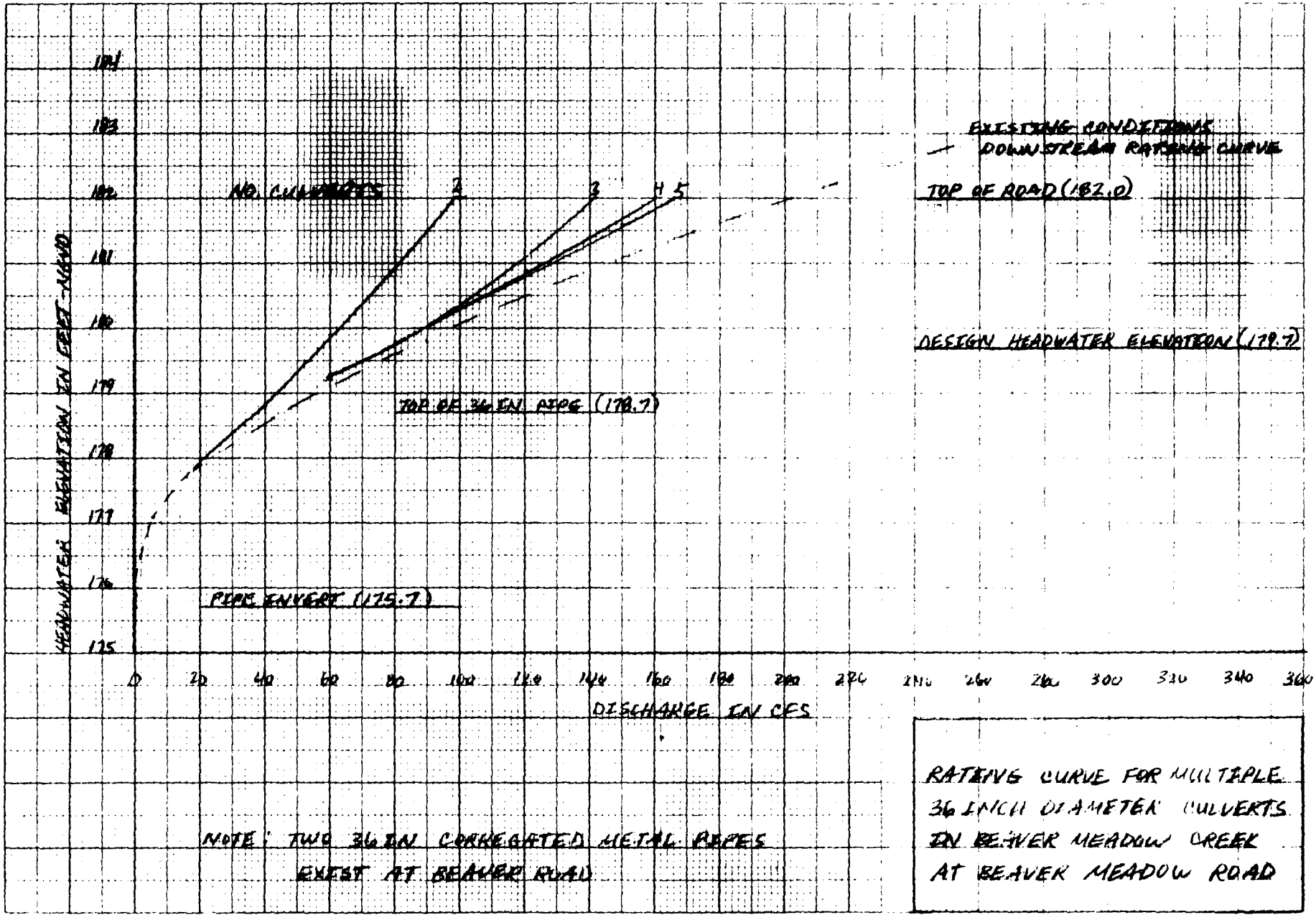


NOTE: PROFILE DETERMINED FROM NYSDOT TOPOGRAPHIC MAPS

PROFILE OF BEAVER MEADOW ROAD IN VICINITY OF BEAVER MEADOW CREEK

PLATE 3

GRAPH PAPER | KEUFFEL & ESSER CO.



NOTE: TWO 36 IN CORRUGATED METAL PIPES EXIST AT BEAVER ROAD

RATING CURVE FOR MULTIPLE 36 INCH DIAMETER CULVERTS IN BEAVER MEADOW CREEK AT BEAVER MEADOW ROAD

PLATE 4

GRAPH PAPER GRAPHIC CONTROLS CORPORATION
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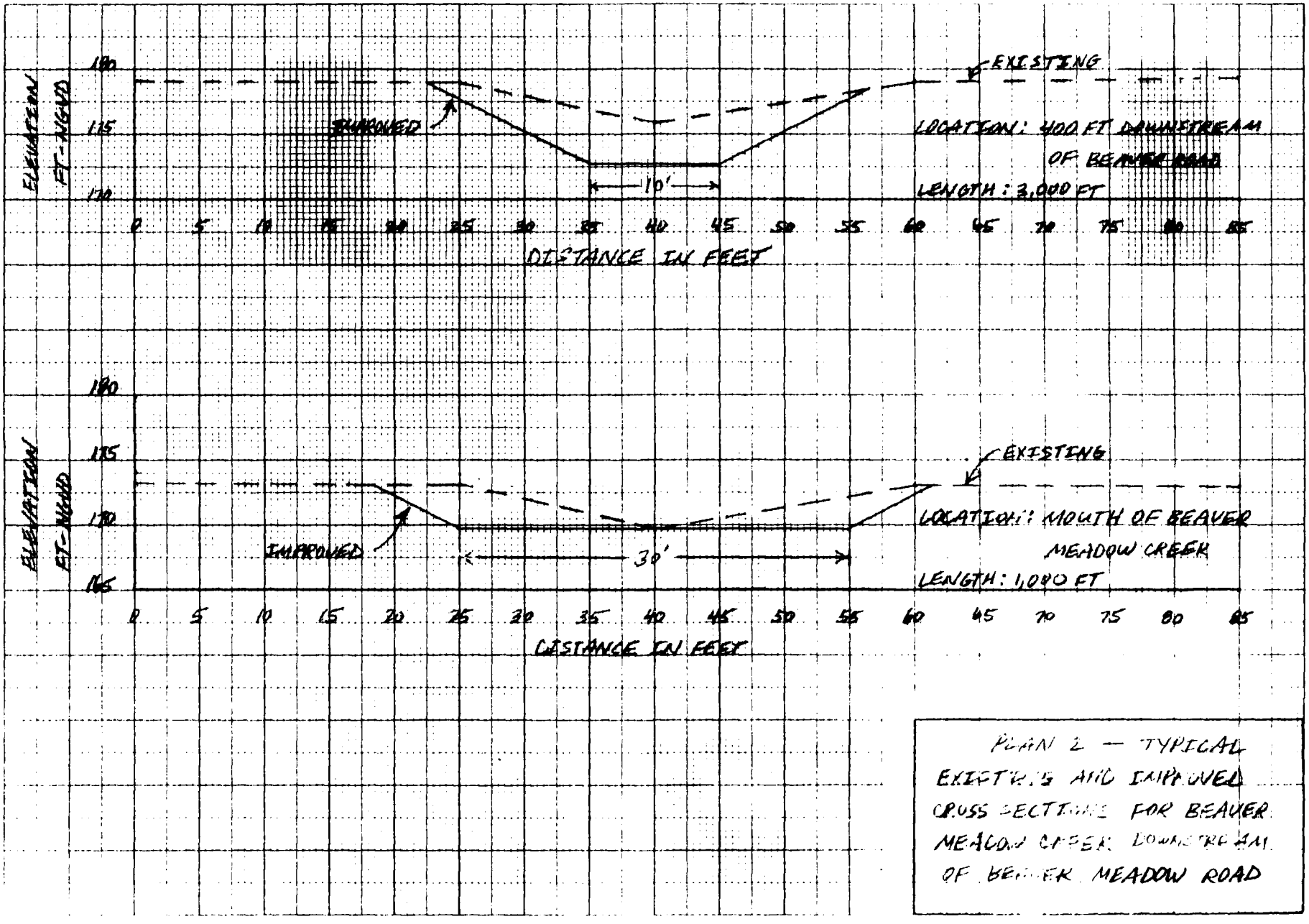
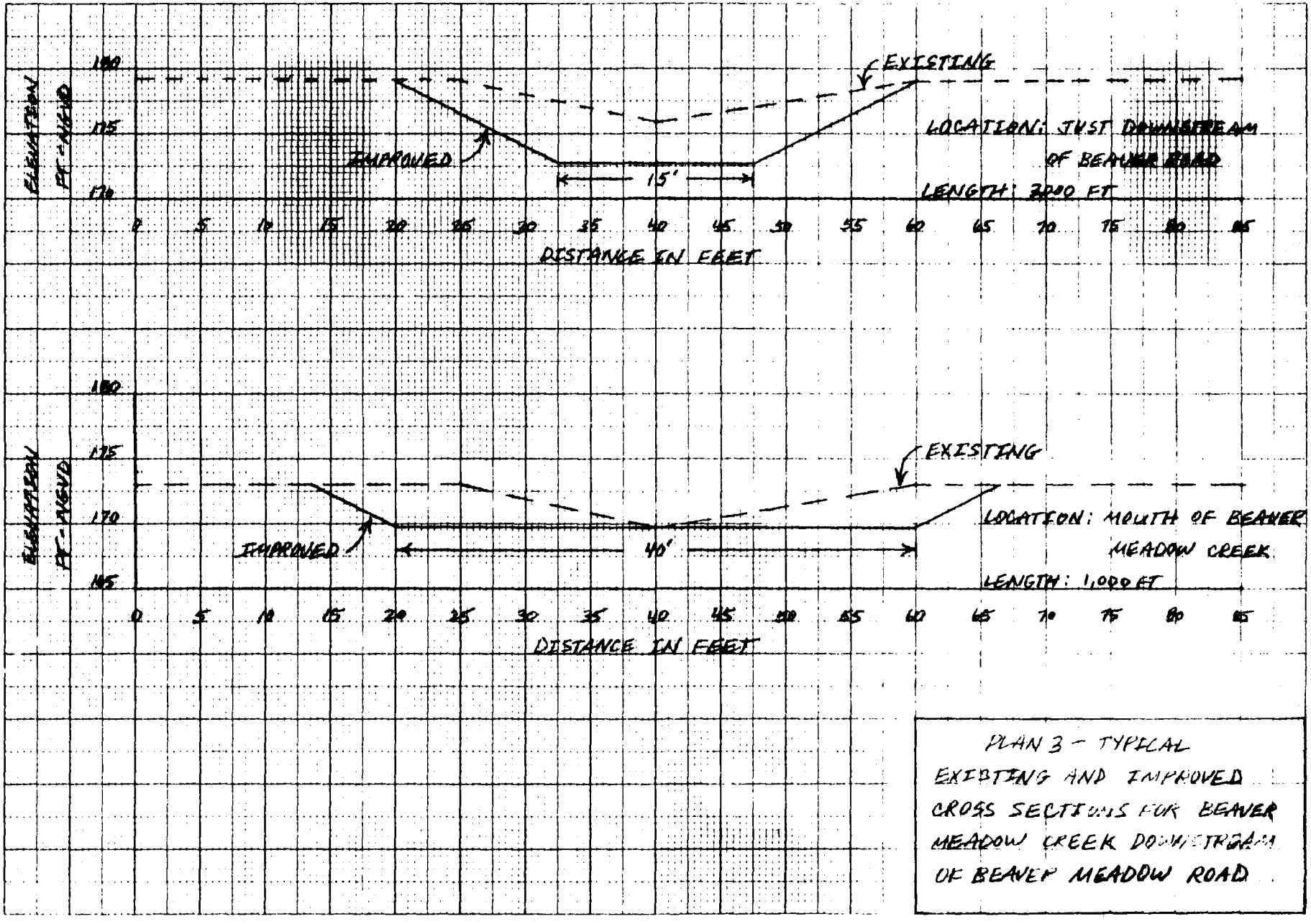
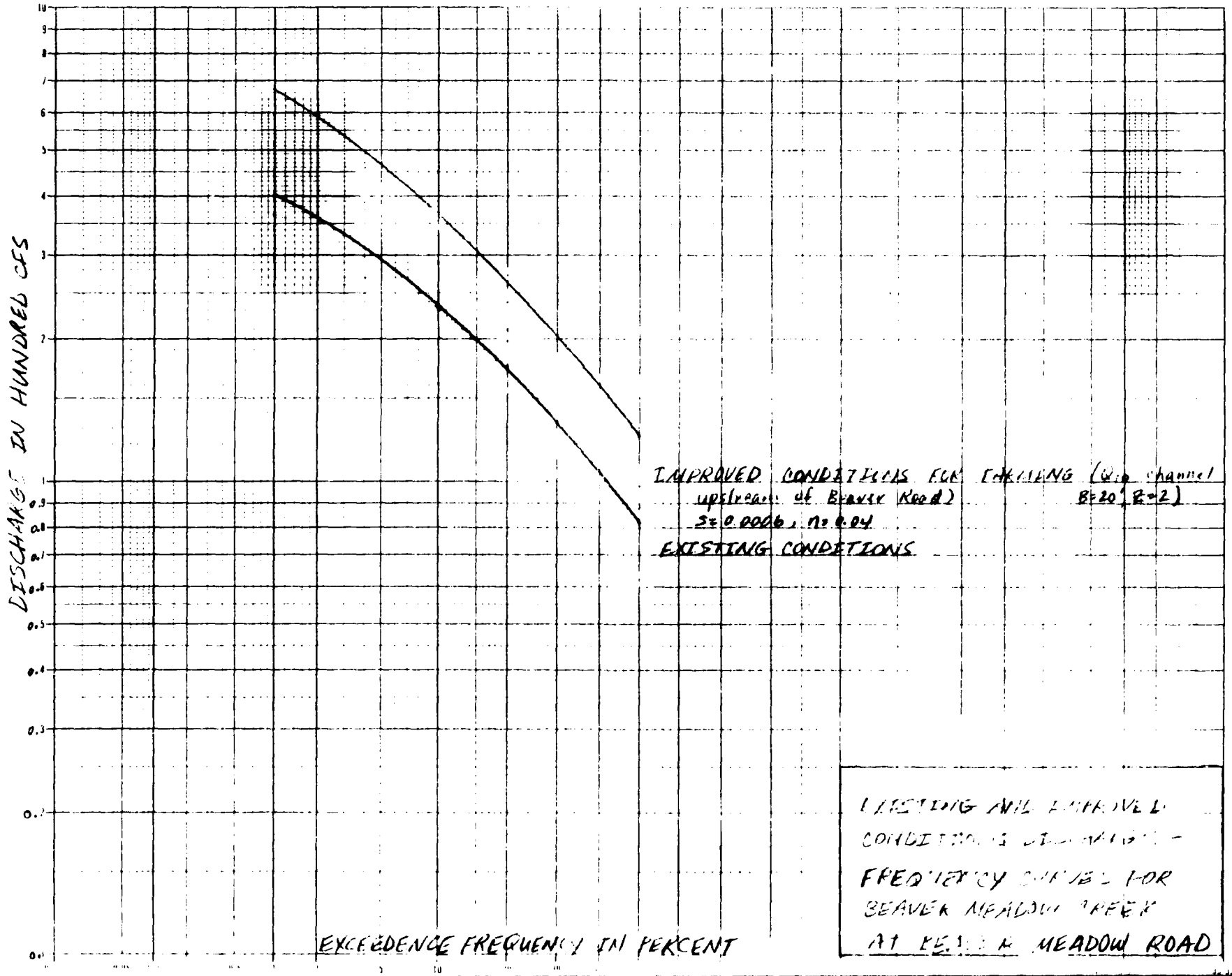


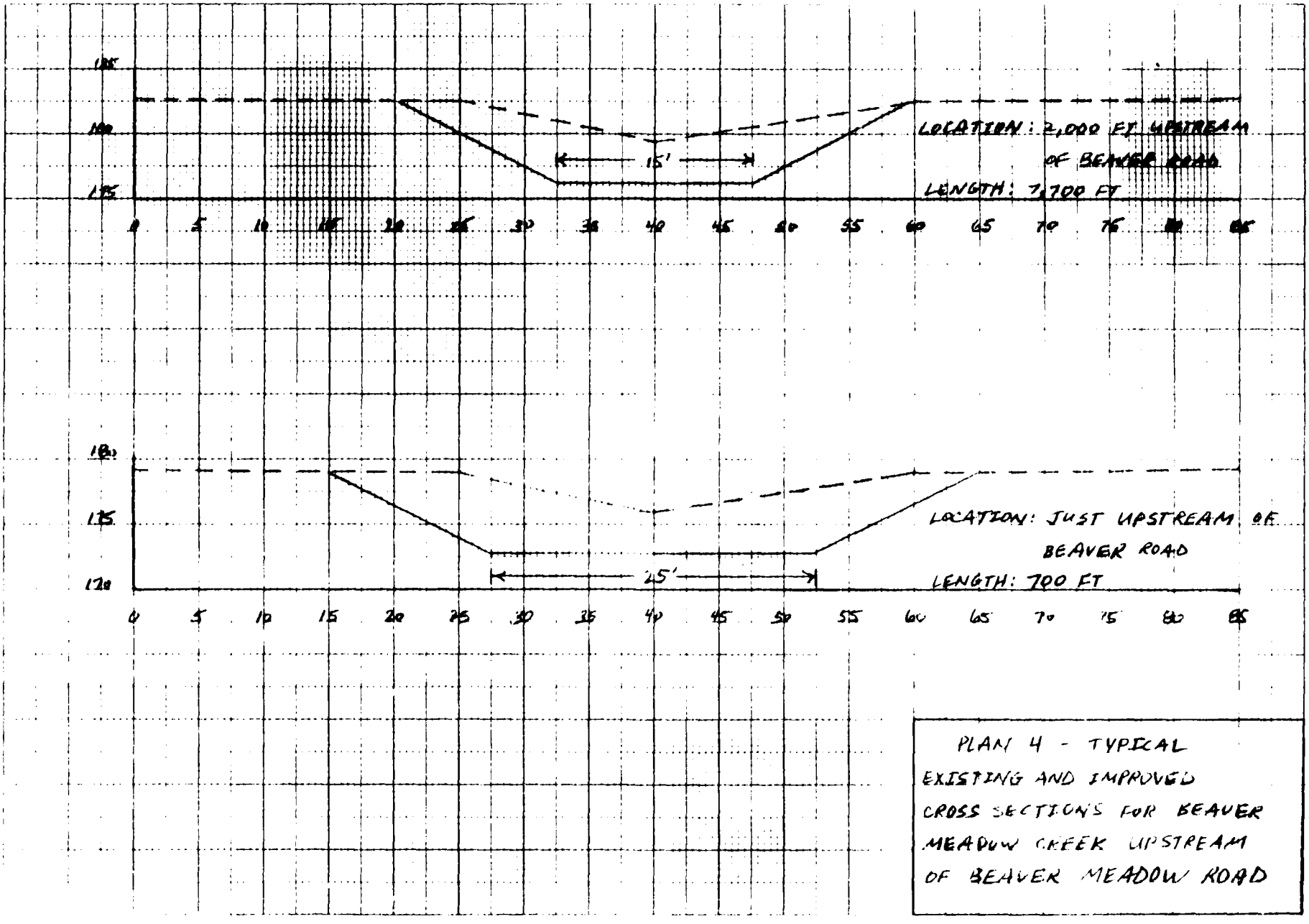
PLATE 2 — TYPICAL EXISTING AND IMPROVED CROSS SECTIONS FOR BEAVER MEADOW CREEK DOWNSTREAM OF BEAVER MEADOW ROAD



PLAN 3 - TYPICAL EXISTING AND IMPROVED CROSS SECTIONS FOR BEAVER MEADOW CREEK DOWNSTREAM OF BEAVER MEADOW ROAD

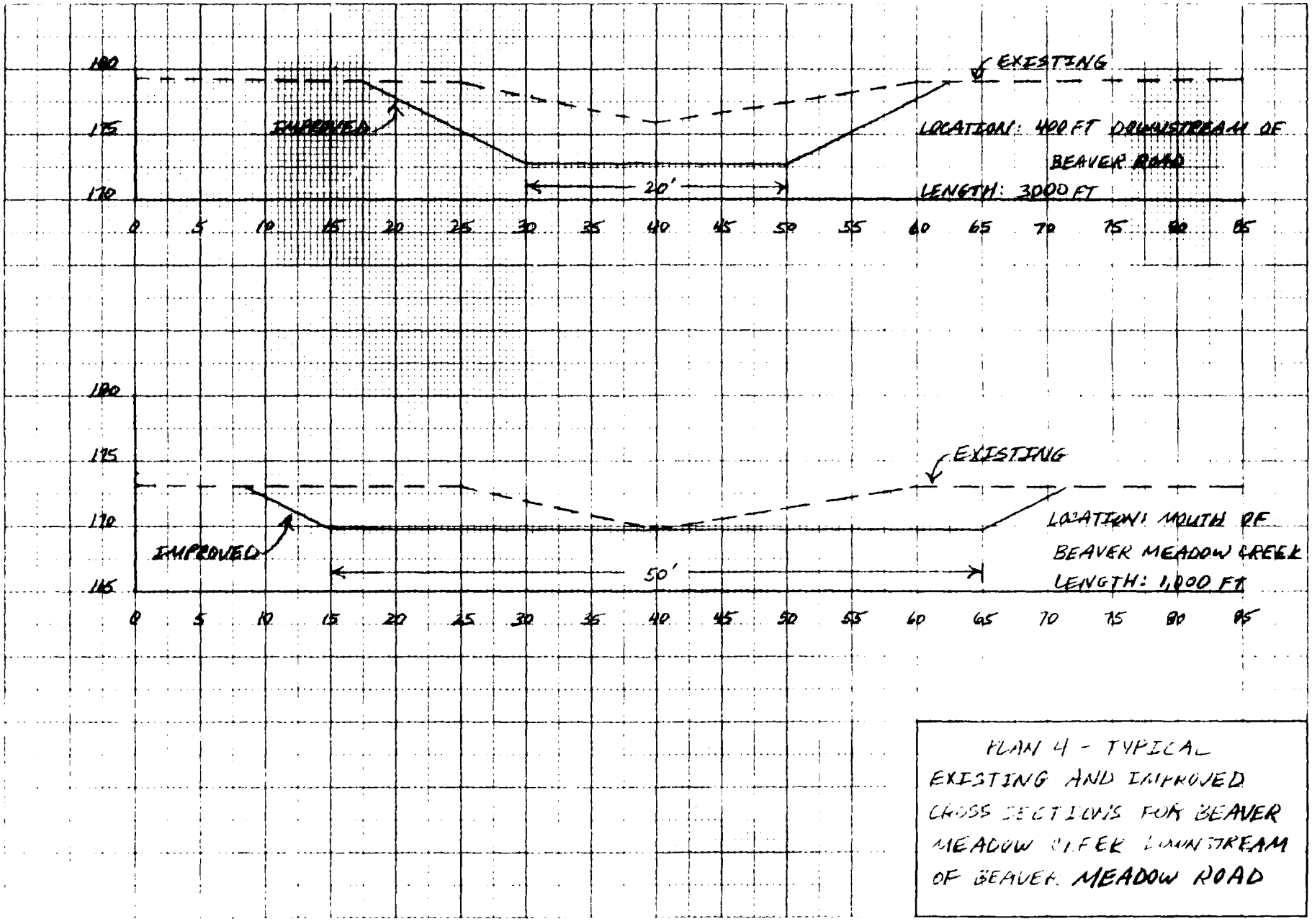
PLATE 6


DISCHARGE IN HUNDRED CFS
EXCEEDENCE FREQUENCY IN PERCENT
IMPROVED CONDITIONS FOR EXISTING (w/o channel upstream of Beaver Road) B=20', Z=2
S=0.0006, n=0.04
EXISTING CONDITIONS
EXISTING AND IMPROVED CONDITIONS DISCHARGE-FREQUENCY CURVES FOR BEAVER MEADOW CREEK AT BEAVER MEADOW ROAD



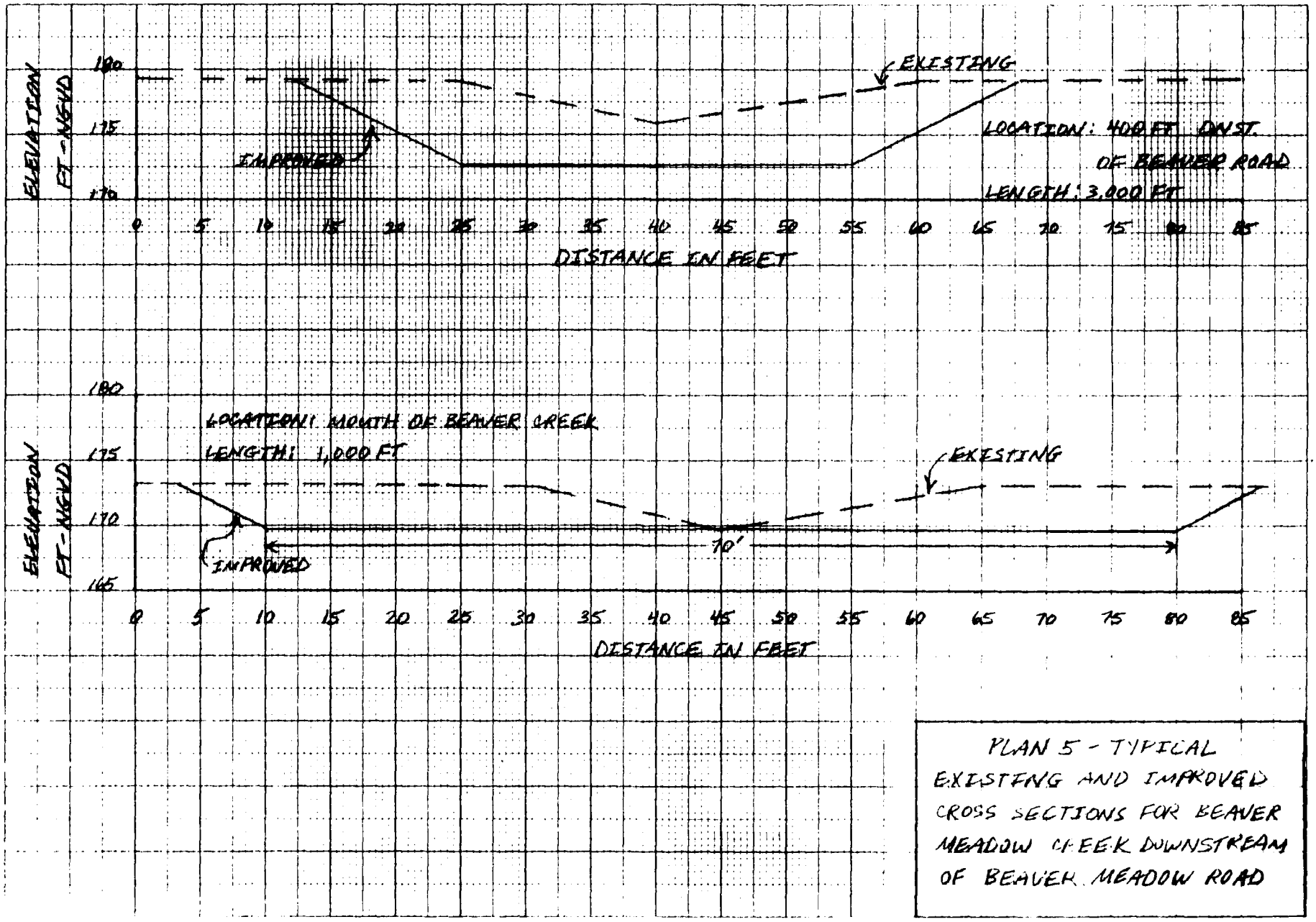
PLAN 4 - TYPICAL EXISTING AND IMPROVED CROSS SECTIONS FOR BEAVER MEADOW CREEK UPSTREAM OF BEAVER MEADOW ROAD

PLATE 9



PLAN 4 - TYPICAL EXISTING AND IMPROVED CROSS SECTIONS FOR BEAVER MEADOW CREEK DOWNSTREAM OF BEAVER MEADOW ROAD

PLATE 1



PLAN 5 - TYPICAL EXISTING AND IMPROVED CROSS SECTIONS FOR BEAVER MEADOW CREEK DOWNSTREAM OF BEAVER MEADOW ROAD

PLATE 10